DOCUMENT RESUME

ED 309 316 CE 052 978

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TITLE Skills and Knowledge Needs Assessment To Support Multi-Craft Maintenance and Training Design. Report Number Four.
INSTITUTION Pennsylvania State Univ., University Park. Inst. for Research in Training and Development.
PUB DATE Nov 87
NOTE 50p.
PUB TYPE Reports - Research/Technical (143)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Adult Vocational Education; Curriculum Development; Electricians; Hydraulics; *Industrial Personnel; *Industrial Training; Instrumentation Technicians; Job Analysis; Machine Repairers; Mechanics (Process); *Needs Assessment; *On the Job Training; Plumbing

ABSTRACT

The needs assessment reported in this document was undertaken to identify the skills and knowledge needed in the maintenance department of Standard Steel of Burnham, Pennsylvania, so that curriculum could be developed to: (1) train most department employees for most tasks across crafts; and thereby (2) increase productivity by decreasing the time spent arranging for a number of workers on each job. The document consists of an introduction and several matrices. The introduction lists the crafts involved (riggers, pipe fitters, electricians, mechanics, tinners, hydraulics workers, instrument workers, and maintenance machinists) and describes how the skills and knowledge were identified. The matrices present: the general job sequences identified and the function of each task (safety; replace; shutdown; preventive maintenance; start-up and test; and repair, rebuild, and troubleshoot) in relation to each sequence; the areas considered general knowledge required for each craft; and the areas considered specialized knowledge required for each craft. At least half of the document consists of a separate matrix for each craft, which states what knowledge areas are needed to repair which systems. (CML)

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ED309316

Report Number Four

Skills and Knowledge Needs Assessment to Support Multi-craft Maintenance and Training Design

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November 1987

Institute for Research in Training and Development

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INTRODUCTION

In an effort to increase efficiency within the Maintenance Department, Standard Steel of Burnham, Pennsylvania, decided to design and to implement a skill curriculum. Specifically, the Maintenance Department, which had been divided into eight distinct craft areas, would eventually become a single area, in which each employee would be qualified to do the majority of maintenance jobs. It was the task of a team from the Penn State University Institute for Research in Training Development, (IRTD), to perform a needs assessment that would identify those basic skills that are required to perform the jobs within each of the crafts. The identification of these skills then would be used to develop a curriculum aimed at increasing the basic knowledge to acceptable levels. It was hypothesized that if any one maintenance worker possessed the skills to perform most maintenance tasks, productivity would increase. This increase would result from a reduction in the time spent arranging for a number of workers on each job. For example, if a repair was required on a small electric motor which might normally have required a rigger, an electrician and a mechanic, now that same job could be completed by one person.

With this purpose in mind, a process was developed which would insure that the largest number of skills could be identified. The remainder of this summary will focus on that process. The crafts which would be involved in the needs assessment included: Riggers, Pipe Fitters, Electricians, Mechanics, Tinners, Hydraulics, and Maintenance Machinists. The process presented in Figure 1 was used to identify the skills needed for each of the crafts. For example, the researchers conducted step one through step six for Riggers and then again for Electricians and so on, for each of the crafts.

Specifically, after a craft was pinpointed, the researchers met with the foremen of that craft. This meeting consisted of a thorough explanation of the researchers' purpose, as well as the specific information needed from the foreman. It was important that the foreman understood which information was needed and how it had to be organized. It was explained that initially it was important to identify all of the machines or systems of machines for which the workers in his craft area would be responsible. Then, the specific jobs or sequences of jobs for each machine had to be identified. For example, when talking with the foreman of the mechanics, if he identified the AFM machine as being a machine for which mechanics were responsible, the foreman was asked to list which tasks he might perform on the AFM. These tasks might include "repair, replace or align," to name a few. In addition to identifying the tasks performed on each machine, the foreman was asked what types of knowledge would be necessary to complete the job. For example, a mechanic repairing an AFM machine, would need a basic understanding of mechanical principles as well as an understanding of its construction and design. This, then, would be labeled general knowledge or knowledge that would be useful for mechanics in other steel mills or industries. Another type of knowledge which needed to be identified, was called specialized knowledge. Specialized knowledge is knowledge specific to the Standard Steel plant. However, specialized knowledge, or plant specific knowledge, was not found to play an important role in most of the crafts.

This process of listing the machines, the tasks completed on the machines and the knowledge necessary to carry out the tasks was continued with the foreman until all of the machines had been identified and the task sequences described. Thus generating a list of the majority of the machines. To insure that all the machines were identified, however, a walkthrough was conducted.

The walkthrough with the foreman was the second step in the process presented in Figure 1. At this point, the foreman was asked to conduct a tour of the plant accompanied by the researchers. He was asked to identify those machines that had not previously been identified, with which the men in his craft area would come in contact. Often it was found that these tours served as good methods for triggering memories. The foreman frequently would identify several machines that previously had been forgotten. Again, the foreman was asked to list those tasks which might be completed on that machine and the knowledge needed to carry out the task.

After the walkthrough, the researchers organized and condensed the information. The researchers then returned with a clean copy of the list of machines and tasks for that craft. The foreman was asked to review the list. This review comprised the third step in the process described by Figure 1. The examination of the list by the foreman cleared up any misunderstandings that may have occurred. On one occasion, for example, the researcher had listed a machine as a "ring nail" when the machine being referred to was a ring mill. The process continued, as shown in Figure 1, with an "expert walkthrough." The foreman was asked to allow the researchers to take a tour of the plant with one of the maintenance workers. The goal of this walkthrough was the same as with the foreman. Again, it was often found that the walkthrough provided an excellent mode of identifying and modifying relevant information.

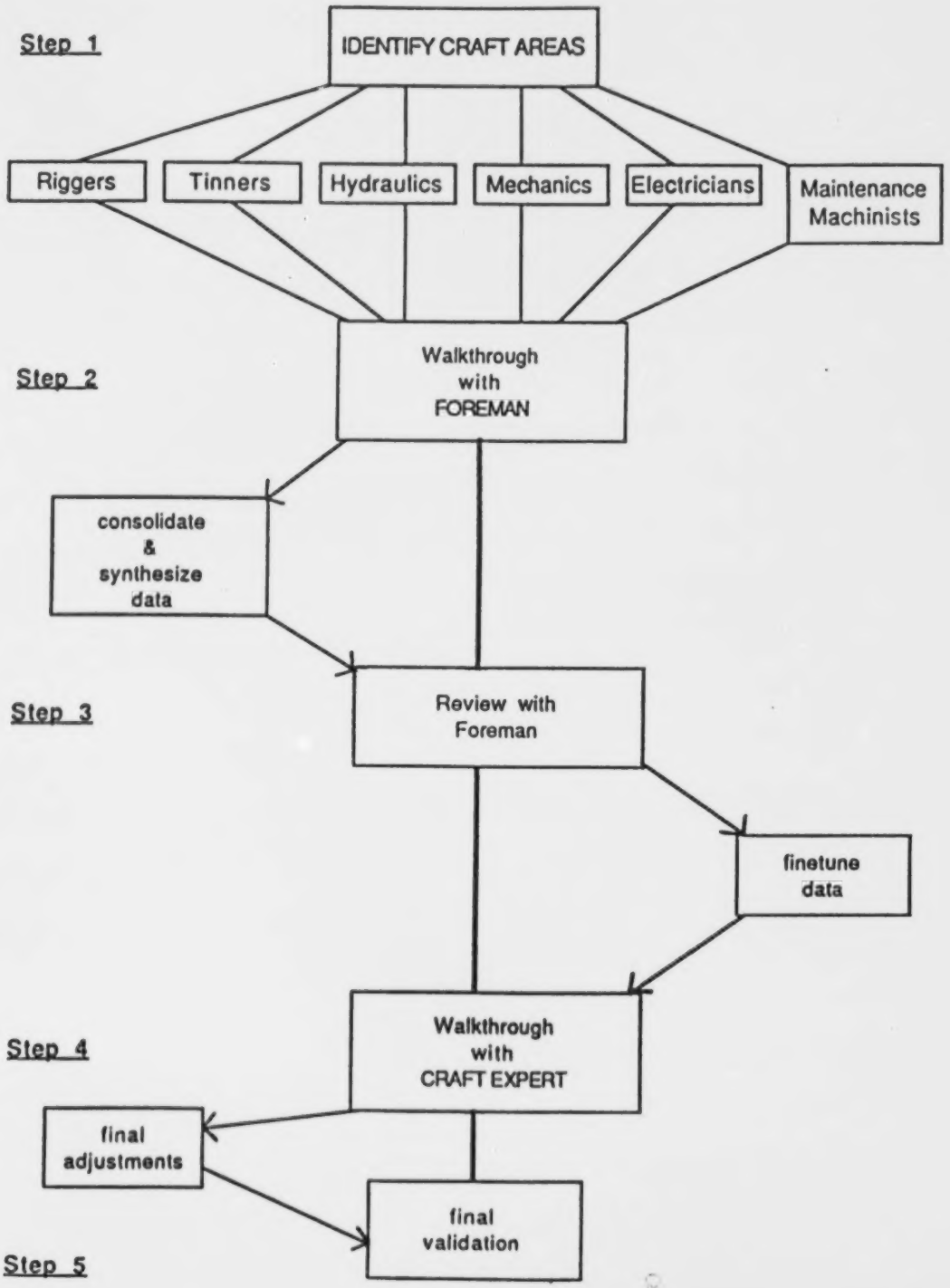
When the researchers updated their lists of tasks and knowledge, they entered the last phase of the process labeled as step 5 on Figure 1. In this phase the researcher had either the foremen or the foreman's supervisor validate the information collected. This final step insured that the information was the best representation of the skills

necessary for each craft area. This process generated eight separate charts, one for each craft area. These charts affect the specific machines and systems, along with the knowledge necessary for the repair of each machine or system for each chart area. Additionally, a chart showing knowledge and skills across all eight craft areas was prepared.

With this information, the second phase of the larger project of developing a curriculum can be started. At that point, it will be important to examine the information collected here, to identify any overlap in the necessary skills that crafts share. This process may aid in deciding on the best structure and content that the curriculum should have. It must also be determined whether the knowledge and skills would be best taught by a vo-tech school, by plant personnel, or by outside vendors.

Figure 1

The Needs Assessment Sequence



CODES:
1 = Safety
2 = Replace
3 = Shutdown
4 = Preventive Maintenance
5 = Start-up & Test
6 = Repair, Rebuild & Troubleshoot

GENERIC SEQUENCES:	HYDRAULICS	MECHANICS	TINNERS	PIPEFITTERS	RIGGERS	ELECTRICIANS	INSTRUMENT	MACHINIST
Accummulators	1 2 3 4 5 6							
Guards:			2 6					
- Chain			- -					
- Gear			- -					
- Scale			- -					
Duct Systems:			2 6	1 2 6				
- Exhaust			- -					
- Combat			- -					
Degreaser				1 2 3 4 5 6				
Valves	1 3 6							
Centrifuges	1 2 3 5 6							
Conveyors		1 2 4 5 6	2 6		1 2 6	1 2 3 4 5 6		1 2 4 5 6
Shot Blast Systems		1 2 4 5 6			1 2 6	1 2 4 5 6		
Dust Collectors		1 2 3 4 5 6			2 6	1 2 3 4 5 6		
Oil Skimmers		1 2 6			1 2 6	1 2 3 4 5 6		
Hammers		1 2 3 4 5 6			1 2 6			
Presses		1 2 3 4 5 6		1 2 3 6	1 6	1 2 3 4 5 6		
Manipulators		1 2 4 5 6			1 2 6	1 2 4 5 6		
Quench System		1 2 3 4 5 6				1 2 4 5 6		
Argon/Oxygen Vessels		1 2 3 4 5 6			1 2 6	1 2 4 5 6		
Ring Mills		1 2 3 4 5 6		1 2 3 6	1 2 6	1 2 3 4 5 6		
Grinders		1 2 3 4 5 6			1 2 6	1 2 4 5 6		1 2 4 5 6
Cranes		1 2 3 4 5 6			1 2 3 6	1 2 4 5 6		
Burning Machines		1 2 3 4 5 6			1 6			
Security Systems							5 6	

	HY	ME	TI	FI	RI	EL	IN	MA
Axle Checking Machine								1 2 4 5 6
Snyder Facing & Turning Machine								1 2 4 5 6
Snyder Wheel Machine								1 2 3 4 5 6
Radial Drill								1 2 4 5 6
Horizontal Boring Machine								1 2 4 5 6
Railway cars & Heavy trucks					1 2 6			
High Voltage Systems						1 2 3 4 5 6		
Back-up Generating Systems					1 3 4 5 6			
General Lighting						1 2 3 5 6		
Circuit Breakers						1 2 3 4 5 6		
General Plumbing				1 2 3 4 5 6				
Cable Systems						1 2 3 4 5 6	1 3 6	
Transformers						1 2 3 4 5 6		
Vertical Turning Machines:								
- Betts								1 2 4 5 6
- G & L								1 2 4 5 6
- Numerically Controlled								1 2 4 5 6
- Bullard								1 2 4 5 6
Determinators:							5 6	
- Nitrogen-Oxygen							: :	
- Hydrogen							: :	
- Carbon & Sulfer							: :	
Thermocouples							2 5 6	

	HY	ME	TI	PI	RI	EL	IN	MA
Natural Gas Lines				1 2 3 5 6				
Oxygen Lines				1 2 3 5 6				
Steam Lines				1 2 3 5 6				
Hydraulic Lines				1 2 3 5 6				
High Pressure Lines				1 2 3 5 6				
Coolant Lines				1 2 3 5 6				
Fire Lines				1 2 3 5 6				
Helium Lines				1 2 3 5 6				
Argon Lines				1 2 3 5 6				
Nitrogen Lines				1 2 3 5 6				
Inspection Lines								1 2 3 4 5 6
Ladels/Charging Buckets					1 2 6			
Pneumatic Systems				1 2 3 5 6				
CREEP Rupture Tester							5 6	
Monitoring System Sensors							5 6	
Brinnell Machine							5 6	1 2 4 5 6
Optical Pyrometer							5 6	
Panels								
- AC/DC						1 2 3 4 5 6		
- Magnetic								
Finishing & Boring Machine					1 2 6			
Wheel Mill					1 2 6			
Drill Press					1 6	1 2 4 5 6		

	HY	ME	TI	FI	RI	EL	IN	MA
Saws					1 2 6	1 2 4 5 6		
- Tysaman Cut-off								1 2 4 5 6
- Rotary								2 4 5 6
- Fox Cut-off								1 2 4 5 6
- Kaukauna Cut-off								1 2 4 5 6
- Hack								1 2 4 5 6
- Circular								1 2 5 6
- High Speed Band								1 2 5 6
Fan Housings			2	6				
Smoke Stacks			2	6				
Safety Shields (plexiglass)			2	6				
Lathes:								
- Snyder Lathe Complex								1 2 4 5 6
- Horizontal								1 2 4 5 6
K & T Lines								1 2 3 4 5 6
Pumps		1 2 3 4 5 6				1 2 3 4 5 6		
- Vacuum							5	
Safety Mirrors			2	6				
Flashing			2	6				
Floor Plates			2	6				
Signs			2	6				
Heater Boxes			2	6				
Hydraulic Systems:	3 4 5 6							
- Pumps	1 3 4 5 6							
- Hose Pipe								
- Motors	1 2 3 4 5 6							
- Lines								
- Controls							2 5 6	
Retaining Rings				6				
Protectives:			2					
- Asbestos			:					
- Rubber			:					

	HY	ME	TI	PI	RI	EL	IN	MA
Motors:								
- DC						1 2 3 4 5 6		
Roof			6					
Air Compressors						1 2 3 4 5 6		
Feed Drives								
Tracers								
Batteries & Chargers						1 2 4 5 6		
Heating Systems				1 2 3 4 5 6			2	6
CRT System						1 2 5 6		
Burners								5
Recorders								
- Chart								
Fixed							2	4 5 6
Portable								
- Electro-Mechanical								5 6
Controls								
- Radio & Video							1 2	5 6
- Combustion								
- Machine						1 2 3 4 5 6		
- Programmable						1 2 3 4 5 6	2	5 6
Meters								
- Electric								
- Gas								
- Fluid							2	5 6
Relays & Relay Systems							2	5 6
Ignition Transformers							2	5 6
Infra-red Detector Systems								5 6
Spectrometer								
- Optical Emissions								5 6
- Simultaneous 28 Channel X-ray								5 6

	HY	ME	TI	PI	RI	EL	IN	MA
Gauges				2 5 6				
Time Clocks						1 2 4 5 6		
Locomotives						1 2 4 5 6		
Magnetic Panels								
Potentiometer								5 6
Switches						1 2 3 4 5 6		
- Solonoid							2	5 6
- Limit							2	5 6
Controller Systems								
- AC Amplifier								5 6
- Electro-magnetic								5 6
- Micro-processor								5 6
AFM					1 6			
- Wear Strips			2					
Furnace Systems		1 2 4 5 6			1 2 6	1 2 3 4 5 6	1 2 3	5 6
- Doors				1 2 3 4 5 6				
- Trucks				1 6				
- Lines				1 2 3 4 5 6				
- Trumpet Brick Support Clamps			2 6					
- Protective Cones & Squares			6					
- Mold Brushes			2 6					
- Wire Brush Spacer			2 6					
- Pressure Control							1 2 3	5 6
- Test Equipment				1 2 5 6				
- Roof Ring				1 2 3 5 6				
- Combustion							1 2 3	5 6
Pressure Regulators							1 2	5 6
Scales							2	5 6
Air Pressure Systems								5
Programmer (Trendtrak)								5 6
Drive Units							2	5 6

CODES;
D = Design
T = Type
P = Principles
A = Application
C = Characteristics

	HYDRAULICS	MECHANICS	TINNERS	PIPEFITTERS	RIGGERS	ELECTRICIANS	INSTRUMENT	MACHINIST
General Knowledge								
Welding			X					X
- Braising				X				
- Electric				X			X	
Arc								
TIG								
MIG								
Spot			X					
- Oxygen Burning (Hogging)					X			
Sheet Metal								
- Saw/shear			X					
- Punch/fasten			X					
- Bend			X					
- Roll			X					
- Drill			X					
Compression systems theory				X				
Silver Soldering				X				
Basic Mechanics	X	X			X	X	X	
Pneumatic systems								
- Controls (TPA)	X						X	X
- Theory	X						X	X
- Pumps & Diaphragms (TACP)								X
Rigging Gear:								
- Cables (TAC)		X			X	X		
- Chains (TAC)					X			X
- Scaffolds (TC) design & methods					X			
- Ropes & Knots (TC)					X			
- Assembly					X			X
- Disassembly					X			X

	HY	ME	TI	PI	RI	EL	IN	MA
General Knowledge (cont.)								
Hydraulics:								
- Theory	X			X			X	X
- Valves (TA)	X							
- Pumps (TPA)	X							
- Relief valves (TPA)	X							
- Seals (TA)	X							
- Packing (TC)	X							
- Oil (TC)	X							
- Filters (TAC)	X							
- Motors (TAC)	X							
- Pistons (TAP)	X	X						
- Couplings (TAC)	X	X						
AC Electricity								
- High voltage Tech.						X		
- Multiplex cables						X		
- Electro-magnet test.						X		
- Resistance						X		
- Electrical code						X		
- Wires and cables (TAC)						X		
- Cable testing						X		
- Circuitry						X		
- Theory						X	X	
- Switches						X		
- Controls						X		
Pipe								
- Preparation (O2)				X				
- Schedules	X			X				
- Fittings				X				
- Couplings				X				X
- Flairs				X				
- Flange repair (gas)				X				
- Sleeving				X				
- Hangar Design				X				
Meter Systems								
- Gas & Oil (TAP)							X	

	HY	ME	TI	PI	RI	EL	IN	MA
General Knowledge (cont.)								
Solonoids (TP)							X	
Basic Physics							X	
Computers							X	
- Chart Recorder & Controllers (TAP)						X		
- CNC Controls (TAP)							X	
- Micro-processors control theory programming								
Print and Transfer:								
- Layout				X				
- Blueprint reading	X	X	X	X	X			X
- Schematic reading								
Hydraulic	X		X	X				
Electronic								
Electrical						X		
Mechanical		X						
Electronics						X	X	
- Micro-chip Circuitry (TDP)							X	
- Integrated Circuits						X		
- Relay Logic						X		
- Circuit Board						X		
layout & design								
debugging								
- Electro-mechanical Servos (TAP)						X		X
- Controls Systems (TAC)						X		
- RF & Video Circuitry (DPA)						X	X	
DC Electricity								
- Theory						X		
- DC Technology						X		
- Battery Technology						X		

	HY	ME	TI	PI	RI	EL	IN	MA
General Knowledge (cont.)								
Chemicals/Gases Properties of:								
- Trichloroethylene				X				
- Propane				X				
- Fuel oil				X				
- Nitrogen				X			X	
- Caustic Acid				X				
- Argon				X			X	
- Helium				X				
- Hydrochloric acid			X					
- Oxygen				X	X		X	
- Hydrogen							X	
Basic Chemistry							X	
Metallurgy (TACP)			X					
Tap, Die & Threading	X							
Combustion								
- Theory							X	
- Controls (TACP)							X	
Sonics Theory (ACP)							X	
Photo Cell (PA)							X	
Optics Theory (AP)							X	
Thermocouples (TP)							X	
Pressure Regulators (TA)							X	
Lubricants (TAC)								X
Specialized Materials Properties of:								
- Asbestos			X					
Dynatrols								X
Cams								X
Chain Drives		X						

	HY	ME	TI	PI	RI	EL	IN	MA
General Knowledge (cont.)								
Mechanical								
- General theory		X			X			X
- Pulleys (TACP)		X			X			X
- Rollers (TACP)					X			X
- Levers (PA)					X			X
- Pistons (TAP)		X						
- Valves (TAP)								X
- Gears (TAP)		X						X
- Clutches (TAP)		X						X
- Cylinders (TAP)		X						X
- Bearings (TAP)		X						X
Babbet		X						
Roller								
Ball								
- Brakes (TAP)		X						
- Screws (TAP)								X
Worm (lead) screw		X						
Jack screw		X						
Conveyor screw		X						
Ball Screw								X
-Sprockets (TAP)		X						X
- Belts (TAP)		X						X
- Drive shaft (TAP)		X						
- Couplings (TAC)		X						
- Load Weight & Balances (TP)					X			
- Rachets (TAC)								X
- Bushings								X
- Clamp systems (TACP)					X			
- Impeller Shaft		X						
- O Rings		X						
- Packing		X						
Counterbalance Springs								X
Filters								X
Hack Stones								X

CODES: T = Types M = Metals P = Properties A = Applications C = Characteristics	HYDRAULICS	MECHANICS	TINNERS	PIPEFITTERS	RIGGERS	ELECTRICIANS	INSTRUMENT	MACHINIST
SPECIALIZED KNOWLEDGE								
Rolling Copper				X				
Crane Movement Signals					X			X
Calculate Cylinder								
- Tonnage	X							X
- Volume	X							
Test Bench Operations (Hydraulics)	X							
Callibration								
- Portable Recorders							X	
- Thermocouples							X	
- Optical Pyrometer							X	
- Portable Potentiometer							X	
- Furnace Burners							X	
- Scales							X	
Electricity Consumption Calculations						X		
Location of:								
- Water Shut-off Valves				X				
- Meters						X		

ELECTRICIANS

KNOWLEGE	SYSTEMS REPAIRED: CRT systems	High voltage systems	Cable systems	DC/AC panels	Back-up generating systems	Dust collectors	General lighting	EQUIPMENT REPAIRED: Motors and pumps	Switches	Machine controls	Programmable controls	Circuit breakers	Transformers	Cranes	Conveyors	DC Motors	Batteries and chargers	Locomotives	Meter reading
Generic Sequences (item specific)																			
Safety	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Replace	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	
Shutdown		X	X	X	X	X	X	X	X	X	X	X	X		X	X			
Prevent. Maint.		X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	
Start-up & test	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Repair, rebuild & troublshooting	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
General Knowledge																			
Schematic reading	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Electronics		X		X	X	X	X	X	X	X	X	X		X	X	X	X	X	
Computer prog. & panels				X				X		X	X				X				
Multiplex cables	X																		
High voltage technology		X	X		X	X		X	X	X	X	X	X	X					
Mechanical theory												X		X	X				
Cable testing	X	X	X	X	X	X	X	X		X		X	X	X	X			X	
Electro-magnet testing														X					

ELECTRICIANS

KNOWLEGE / EQUIPMENT REPAIRED	Air compressors	Clocks	Furnaces	Oil skimmers	Presses	Manipulators	Coolers	Argon oxygen vessels	Ring mills	Drill presses	Wheelabrators	Grinders	Saws
<u>Generic Sequences (item specific)</u>													
Safety	X	X	X	X	X	X	X	X	X	X	X	X	X
Replace	X	X	X	X	X	X	X	X	X	X	X	X	X
Shutdown	X		X	X	X				X				
Prevent. Maint.	X	X	X	X	X	X	X	X	X	X	X	X	X
Start-up & test	X	X	X	X	X	X	X	X	X	X	X	X	X
Repair, rebuild & troublshooting	X	X	X	X	X	X	X	X	X	X	X	X	X
<u>General Knowledge</u>													
Schematic reading	X	X	X	X	X	X	X	X	X	X	X	X	X
Electronics	X	X	X	X	X	X	X	X	X	X	X	X	X
Computer prog. & panel			X		X	X			X			X	X
Multiplex cables													
High voltage technology	X		X		X				X				
Mechanical theory		X							X		X		
Cable testing	X		X	X	X			X	X				
Electro-magnet testing													

ELECTRICIANS

KNOWLEGE	SYSTEMS REPAIRED: CRT systems	High voltage systems	Cable systems	DC/AC panels	Back-up generating systems	Dust collectors	General lighting	EQUIPMENT REPAIRED: Motors and pumps	Switches	Machine controls	Programmable controls	Circuit breakers	Transformers	Cranes	Conveyors	DC Motors	Batteries and chargers	Locomotives	Meter reading
Resistance	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Electrical code	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
DC Technology		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Battery technology		X		X	X	X	X	X	X	X	X					X	X	X	
Electricity	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Wires & cables properties of	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Specialized Knowledge																			
Plant specific applications of :																			
- motors		X			X	X		X		X		X		X	X	X	X	X	
- controls		X		X	X	X		X		X	X	X		X	X	X	X	X	
meter location	X	X	X	X			X												X
substation control location		X	X	X	X	X	X	X	X	X		X	X						
back up generating start-up procedure		X			X		X		X	X									
electricity consumption calculations		X																	X

ELECTRICIANS

KNOWLEGE / EQUIPMENT REPAIRED	Air compressors	Clocks	Furnaces	Oil skimmers	Presses	Manipulators	Coolers	Argon oxygen vessels	Ring mills	Drill presses	Wheelabrators	Grinders	Saws
Resistance	X	X	X	X	X	X	X	X	X	X	X	X	X
Electrical code	X	X	X	X	X	X	X	X	X	X	X	X	X
DC Technology	X		X	X	X	X	X	X	X	X		X	X
Battery technology	X	X	X						X				
Electricity	X	X	X	X	X	X	X	X	X	X	X	X	X
Wires & cables properties of	X	X	X	X	X	X	X	X	X	X	X	X	X
Specialized Knowledge													
Plant specific applications of : - motors	X	X	X	X	X	X	X	X	X	X	X	X	X
- controls					X	X							
meter location													
substation control location			X						X				
back up generating start-up procedure			X						X				
electricity consumption calculations													

HYDRAULICS

KNOWLEDGE	Hydraulic Pumps	Hydraulic Systems	Accumulators	Valves	Hydraulic Hose & Pipe	Centrifuges	Hydraulic Motors	Hydraulic Flexible Hoses
Generic Sequences (item specific)								
Safety	X		X	X		X	X	
Replace			X			X	X	
Shutdown	X	X	X	X		X	X	
Prevent. Maint.	X	X	X				X	
Start-up & Test	X	X	X			X	X	
Repair, rebuild & troubleshoot	X	X	X	X		X	X	
General Knowledge								
Basic Mechanics	X	X	X	X		X	X	
Pneumatic Systems								
- Controls			X	X				
- Theory			X	X				
Hydraulics								
- Theory	X	X	X	X	X	X	X	X
- Valves		X		X	X	X	X	X
- Pumps	X	X			X	X	X	X
- Relief Valves		X		X	X	X	X	X
- Seals	X	X	X	X	X	X	X	X
- Packing	X	X		X				
- Oil	X	X	X	X	X	X	X	X
- Filters				X	X	X	X	X
- Motors		X		X		X	X	
Blueprint Reading	X	X	X	X	X	X	X	X
Schematic Reading (Hydraulic)	X	X	X	X	X	X	X	X

Specialized Knowledge					
Pipe Schedules	Tap, Die & Threading	Test Bench Operations	Calculate Cylinder - tonnage	- volume	
×	×	×		×	Hydraulic Pumps
×	×	×	×	×	Hydraulic Systems
×	×	×		×	Accumulators
×	×	×	×	×	Valves
×	×	×	×	×	Hydraulic Hose & Pipe
	×			×	Centrifuges
×	×	×			Hydraulic Motors
×	×	×	×	×	Hydraulic Flexible Hoses

INSTRUMENT

KNOWLEDGE	Furnace Systems - Pressure Controls - Combustion	Security Systems	Cable Systems	Determinators: - Nitrogen-Oxygen - Hydrogen - Carbon & Sulfer	Thermocouples	CREEP Rupture Tester	Monitoring System Sensors	Brinnell Machine	Optical Pyrometer	Vacuum Pumps	Hydraulic Controls	Heating Systems	Burners	Chart Recorders	Radio & Video Controls	Programmable Controls	Fluid Meters	Relays & Relay Systems	Ignition Transformers	Infra-red Detector Systems	Spectrometer - Optical Emissions - Simultaneous 28 Channel X-ray	Potentiometer	Solonoid Switches	Limit Switches	AC Amplifier Controller System	Electro-magnetic Controller System	Micro-processor Controller System
Generic Sequences (item specific)																											
Safety	X X		X												X												
Replace	X X				X						X	X		X	X	X	X	X	X				X	X			
Shutdown	X X		X																								
Prevent. Maint.														X													
Start-up & Test	X X	X		XXX	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Repair, rebuild & troubleshoot	X X	X	X	XXX	X	X	X	X	X		X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X
General Knowledge																											
Basic Electronics		X	X	XXX	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Pneumatic Systems - Controls - Theory	XX			XXX						X					X						X	X					
Hydraulics Theory	XX			X X						X							X						X				
AC Electricity - Theory		X	X		X			X		X				X	X			X					X	X	X	X	
Meter Systems - Gas & Oil				XXX		X				X					X						X	X					
Solenoids	XX			XXX		X			X		X			X	X		X			X	X	X	X				
Basic Physics				XXX																	X	X					
Micro-chip Circuitry		X		XXX		X				X	X			X	X		X			X	X	X		X			X
Basic Mechanics	X			XXX		X				X	X			X	X		X			X	X	X	X	X			

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INSTRUMENT

KNOWLEDGE	Pressure Regulators	Scales	Air Pressure Systems	Programmer (Trendtrak)	Drive Units	Computer	Electro-Mechanical Recorder
Generic Sequences (item specific)							
Safety	X						
Replace	X	X			X		
Shutdown							
Prevent. Maint.							
Start-up & Test	X	X	X	X	X		
Repair, rebuild & troubleshoot	X	X		X	X		
	X	X		X			
General Knowledge							
Basic Electronics	X	X	X	X	X		
Pneumatic Systems - Controls - Theory		X			X	X	
Hydraulics Theory			X		X		
AC Electricity - Theory							
Meter Systems - Gas & Oil				X	X	X	
Solenoids			X	X	X	X	X
Basic Physics		X	X			X	X
Micro-chip Circuitry			X		X	X	
Basic Mechanics		X	X	X	X	X	X

INSTRUMENT

KNOWLEDGE	Furnace Systems - Pressure Controls - Combustion	Security Systems	Cable Systems	Determinators: - Nitrogen-Oxygen - Hydrogen - Carbon & Sulfer	Thermocouples	CREEP Rupture Tester	Monitoring System Sensors	Brinnell Machine	Optical Pyrometer	Vacuum Pumps	Hydraulic Controls	Heating Systems	Burners	Chart Recorders	Radio & Video Controls	Programmable Controls	Fluid Meters	Relays & Relay Systems	Ignition Transformers	Infra-red Detector Systems	Spectrometer - Optical Emissions - Simultaneous 28 Channel X-ray	Potentiometer	Solenoid Switches	Limit Switches	AC Amplifier Controller System	Electro-magnetic Controller System	Micrp-processor Controller System
General Knowledge																											
RF & Video Circuitry	x x x			xxx	x	x	x							x	x						x						
Properties of: - Nitrogen				x x																							
- Argon				xxx																	xx						
- Oxygen	x			xxx																							
- Hydrogen				x													x										
Basic Chemistry				xxx																	xx						
Combustion - Theory - Controls	x x			xxx							x						x		x								
Sonics Theory										x																	
Photo Cell	x x			xxx										x					x	x	xx						
Optics Theory				xxx					x					x						x	xx						
Thermocouples				xx	x	x				x																	
Pressure Regulators	x x			xxx					x	x					x		x			x	xx						
Specialized Knowledge																											
Callibration: - Portable Recorders						x								x			x			x	xx			x	x		
- Thermocouples					x	x				x															x		
- Portable Potentiometer						x				x																	
- Furnace Burners																							x				
- Scales																											
- Pressure Regulators	x x			xxx						x	x			x	x					x	xx						

INSTRUMENTS

	Scales	Air Pressure Systems	Programmer (Trendtrak)	Drive Units	Computers	Electro-Magnetic Recorder
General Knowledge						
RF & Video Circuitry				X	X	
Properties of: - Nitrogen						
- Argon						
- Oxygen						
- Hydrogen						
Basic Chemistry						
Combustion - Theory - Controls						X
Sonics Theory				X	X	
Photo Cell				X	X	
Optics Theory				X	X	
Thermocouples	X		X	X	X	
Pressure Regulators		X		X	X	X
Specialized Knowledge						
Calibration: - Portable Recorders	X	X			X	X
- Thermocouples		X				X
- Portable Potentiometer			X		X	X
- Furnace Burners		X		X		

MAINTENANCE MACHINISTS

KNOWLEDGE	SYSTEMS REPAIRED				MACHINES REPAIRED	Vertical turning machines																						
		K & T line	Inspection line	Snyder lathe complex [AFM]		Betts & G & L	Bullard	Numerically controlled	Axle checking machine	Brinnell machine	Balancing machine	Snyder facing & centering machine	Horizontal lathes	Snyder wheel machines	Ty saman cut-off saw	Rotary saws	5412 planer	Grinders	Radial drill	Fox cut-off saw	Kaukauna cut-off saw	Horizontal boring machines	Hack saws	Circular saws	Chip conveyors	High speed band saws
Generic Sequence (item specific)																												
Safety		X	X	X		X	X	X	X	X		X	X	X	X			X	X	X	X	X	X	X	X	X		
Replace		X	X	X		X	X	X	X	X		X	X	X	X	X		X	X	X	X	X	X	X	X	X		
Shutdown		X	X									X	X	X														
Prevent. Maint.		X	X	X		X	X	X	X	X		X	X	X	X	X		X	X	X	X	X	X	X	X			
Start-up & test		X	X	X		X	X	X	X	X		X	X	X	X			X	X	X	X	X	X	X	X	X		
Repair, rebuild & troubleshooting		X	X	X		X	X	X	X	X		X	X	X	X	X		X	X	X	X	X	X	X	X	X		
General Knowledge																												
Blueprint reading		X	X	X		X	X	X				X	X	X						X							X	
Tolerances & fits		X				X	X	X		X		X	X	X				X	X			X					X	
Ball screws								X		X			X			X						X						
Numerical codes								X					X									X						
Cams		X					X	X																				
Servos		X		X			X							X					X									
Gears		X		X		X	X	X		X		X	X	X	X	X		X	X	X	X	X	X	X	X			
Bearings		X	X	X		X	X	X						X														
Clutches - mech.		X				X	X	X					X						X		X	X			X			
- electric						X		X					X															

MAINTENANCE MACHINISTS

KNOWLEDGE / SYSTEMS REPAIRED	K & T line	Inspection line	Snyder lathe complex [AFM]	MACHINES REPAIRED	Vertical turning machines: Betts & G & L	Vertical turning machines: Bullard	Vertical turning machines: Numerically controlled	Axle checking machine	Brinnell machine	Balancing machine	Snyder facing & centering machine	Horizontal lathes	Snyder wheel machines	Ty saman cut-off saw	Rotary saws	5412 planer	Grinders	Radial drill	Fox cut-off saw	Kaukauna cut-off saw	Horizontal boring machines	Hack saws	Circular saws	Chip conveyors	High speed band saws
General Knowledge																									
Belts & pulleys			X		X	X				X	X	X	X	X										X	
Lubrication	X		X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Hydraulics	X	X	X			X					X		X	X				X	X		X					
Rollers	X	X						X																		
Sprockets		X																						X	
Chains		X	X																					X	
Diaphragms									X																
Counterbalance springs					X																				
Pumps	X	X	X		X	X	X				X	X	X	X	X			X	X	X					
Valves	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Dynatrols						X																			
Rigging	X		X		X	X	X					X		X											
Bushings					X																				
Feed screws	X		X		X	X						X		X				X							
Welding			X																						
Electrical theory	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Filters	X	X	X		X	X	X				X	X	X	X	X			X	X		X					
Cylinders	X	X	X																						
Jacks		X													X				X						
Electric/hydraulic interaction[1]	X					X																			

MAINTENANCE MACHINISTS

KNOWLEDGE	SYSTEMS REPAIRED				MACHINES REPAIRED	Vertical turning machines																								
		K & T line	Inspection line	Snyder lathe complex (AFM)		Betts & G & L	Bullard	Numerically controlled	Axle checking machine	Brinnell machine	Balancing machine	Snyder facing & centering machine	Horizontal lathes	Snyder wheel machines	Ty saman cut-off saw	Rotary saws	5412 planer	Grinders	Radial drill	Fox cut-off saw	Kaukauna cut-off saw	Horizontal boring machines	Hack saws	Circular saws	Chip conveyors	High speed band saws
Planetary gears						x																								
Machine specific operating sequences		x	x	x		x	x	x	x	x		x	x	x	x	x		x	x			x		x	x	x				
Lift truck operating knowledge																														
Overhead crane operating knlg.		x		x																										
Shafts		x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x				
Ratchets						x		x										x												
Hack stones																		x												
Couplings		x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x				
Pneumatic theory			x					x		x																				

MECHANICS

KNOWLEDGE	SYSTEMS REPAIRED	Furnaces	Conveyors	Shot blast systems	Dust Collectors	MACHINES REPAIRED	Oil skimmers	Hammers	Presses	Manipulators	Quench systems	Argon /Oxygen vessels	Ring mills	Grinders	Cranes	Burning machine	Pumps (water)
Generic Sequences (item specific)																	
Safety		X	X	X	X		X	X		X	X	X	X	X	X	X	X
Replace		X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
Shutdown					X			X	X		X	X	X	X	X	X	X
Prevent. Maint.		X	X	X	X			X	X	X	X	X	X	X	X	X	X
Start-up & test		X	X	X	X			X	X	X	X	X	X	X	X	X	X
Repair, rebuild & troubleshoot		X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
General Knowledge																	
Print reading		X	X	X	X			X	X	X	X		X	X	X	X	X
Pistons		X						X	X	X			X	X	X	X	X
Seals		X	X	X			X	X	X	X	X	X	X	X	X	X	X
Quadrings (Packing)		X						X	X	X	X	X	X	X	X	X	X
O-rings		X	X	X				X	X	X	X	X	X	X	X	X	X
Pulleys		X	X	X			X		X	X			X	X	X	X	

MECHANICS

KNOWLEDGE / SYSTEMS REPAIRED	Furnaces	Conveyors	Shot blast systems	Dust Collectors	MACHINES REPAIRED	Oil skimmers	Hammers	Presses	Manipulators	Quench systems	Argon /Oxygen vessels	Ring mills	Grinders	Cranes	Burning machine	Pumps (water)
General Knowledge																
Gears	X	X	X			X			X	X	X	X	X	X	X	
Clutches	X	X	X					X	X	X	X	X	X	X	X	
Packing sequences	X						X	X	X	X	X	X	X	X	X	
Cylinders	X		X				X	X	X			X	X	X	X	
Bearings (types, loads)	X	X	X			X	X	X	X	X	X	X	X	X	X	X
Brakes	X	X	X					X	X	X	X	X	X	X	X	X
Screws				X			X		X		X	X	X		X	
Sprockets	X		X			X	X	X	X	X	X	X	X	X	X	
Belts		X	X			X		X	X	X		X	X		X	
Impeller shafts			X						X	X		X	X		X	X
Star heads tool													X			
Chain drives	X	X	X			X			X	X		X	X	X	X	
Cables	X								X				X		X	
Machine/system specific tolerances, fits adjustments, alignments	X	X	X			X	X	X	X	X	X	X		X	X	X
Motors	X	X	X	X		X		X	X	X	X	X	X	X	X	X
Lubrication	X	X	X	X		X		X	X	X	X	X	X	X	X	X
Pour Babbet Bearings									X					X		
Worm screw drives		X							X		X		X	X	X	
Screw jacks		X							X			X				
Screw conveyor			X													
Couplings	X	X	X	X				X	X	X	X	X	X	X	X	X
Tubings (lubrication, installation)	X	X	X	X				X	X		X	X		X		X
Overhead crane signals	X	X	X	X			X	X	X	X	X	X	X	X	X	X

PIPEFITTERS

KNOWLEDGE	Furnace doors	Gauges	Natural gas lines	Oxygen lines	Steam lines	Coolant lines	Degreaser	Fire lines	General plumbing	Furnace systems, water, gas, hydr. & air	Furnace test equipment	Hydraulic lines	High pressure lines	Pneumatic system	Helium lines	Argon lines	Heating systems	Nitrogen lines	Roof rings furnaces	Presses	Mills	Furnace cars
Generic Sequences (item specific)																						
Safety	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Replace	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Shutdown			X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	
Prevent. Maint.	X						X		X	X							X					
Start-up & test	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			
Repair, rebuild & troubleshooting	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
General Knowledge																						
Welding gas/ brasing electric	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Blueprint reading	X		X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
Properties caustic acid				X																		
Layout	X		X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
Silver soldering					X		X		X								X					
Properties of trichloroethylene							X															
Schematic reading	X		X	X	X	X	X	X	X	X		X	X	X	X	X	X	X		X	X	

PIPEFITTERS

KNOWLEDGE	Furnace doors	Gauges	Natural gas lines	Oxygen lines	Steam lines	Coolant lines	Degreaser	Fire lines	General plumbing	Furnace systems, water, gas, hydr. & air	Furnace test equipment	Hydraulic lines	High pressure lines	Pneumatic system	Helium lines	Argon lines	Heating systems	Nitrogen lines	Roof ridge furnaces	Presses	Mills	Furnace cars
Hydraulic theory	X	X										X							X	X	X	X
Pipe schedules			X	X	X	X		X	X			X	X									
Compression system theory														X								
Properties of nitrogen																		X				
Properties of Argon																X						
Helium properties															X							
Specialized Knowledge																						
Caustic acid properties & characteristics				X																		
Fittings, couplings, flairs - types, metals & properties			X	X		X		X	X			X	X	X	X	X	X	X				
H2 O shut off valves location (city & service)						X		X	X													
Pipe sleeving (types & characteristics)	X		X	X		X						X	X	X	X	X		X				
Rolling copper							X															
Gasline flange repair			X																			
O2 pipe preparation				X																		
Pipe/tubing bending			X	X	X							X										
Properties of gasket joint material	X		X	X	X	X	X	X	X	X		X	X	X	X	X	X	X				
Pipe Hanger design			X	X	X	X	X	X	X	X		X	X	X	X	X	X	X				
Properties of propane																						

RIGGERS

KNOWLEDGE	SYSTEMS REPAIRED				EQUIPMENT REPAIRED																			
	Furnace systems	Duct systems	Dust collectors		Ring Mills	Drill presses	Synder finishing & boring machines	Shot blast systems	Grinders	Cranes	Conveyors	Ladels/ charging buckets	Hammers	Saws	Argon vessels	Manipulators	Oil skimmers	Presses	AFM machine	Burning machine/ straightening press	Wheel mill	Railway cars & heavytrucks
Generic Sequences (item specific)																						
Safety	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Replace	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X				X	X
Shutdown										X													
Prevent. Maint.																							
Start-up & test			X														X	X					
Repair, rebuild & troubleshooting	X	X	X		X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
General Knowledge																								
Weight & balance	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Cable strength, characteristics & applications	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Chain strength, characteristics & applications	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Mobile crane op.	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Overhead crane op.	X	X	X		X	X	X		X	X	X	X	X	X	X	X		X	X	X	X	X	X	X

RIGGERS

KNOWLEDGE	SYSTEMS REPAIRED			EQUIPMENT REPAIRED																		
	Furnace systems	Duct systems	Dust collectors		Ring Mills	Drill presses	Synder finishing & boring machines	Shot blast systems	Grinders	Cranes	Conveyors	Ladels/ charging buckets	Hammers	Saws	Argon vessels	Manipulators	Oil skimmers	Presses	AFM machine	Burning machine/ straightening press	Wheel mill	Railway cars & heavytrucks
General Knowledge																						
Welding	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Blueprint reading	x	x	x		x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	
Burning	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Portapower jack op.	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Mechanical principles	x				x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Mechanical systems of clamps												x										
Ropes, types & applications	x	x	x		x	x	x	x		x	x		x	x			x	x	x	x	x	
Knots	x	x	x		x	x	x	x		x	x		x	x			x	x	x	x	x	
Scaffolding methods design, types, characteristics	x	x	x							x												
General mechanical: pulleys, rollers																						
																		x	x	x	x	
Specialized knowledge																						
Oxygen burning (Hogging)	x				x	x	x					x	x		x	x		x	x	x	x	
Crane movement signals	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Rigging set up & disassemble	x	x	x		x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	

TINNERS

KNOWLEDGE	Protective cones & squares	Smoke stacks	Fan housings	Safety shields (plexiglass)	Guards (chain, gear, scale)	Duct work (exhaust & combat)	Retaining rings	Floor plates	Flashing	Signs	Safety mirrors	Heater boxes	Trumpet brick support clamp	mold brush	wire brush spacer	roof	conveyor	wear strips (AFM)	rubber asbestos protective curtains
Generic Sequences (item specific)																			
Safety																			
Replace		X	X	X	X	X		X	X		X	X	X	X	X		X		
Shutdown																			
Prevent. Maint.																			
Start-up & test							X												
Repair, rebuild & troubleshoot	X	X	X	X	X	X		X	X		X	X	X	X	X		X		
General Knowledge																			
Welding : - stainless steel - up to 1/8th - aluminum - stick - spot - wire		X	X	X		X		X	X	X		X	X	X	X	X	X		
Math	X												X	X	X		X		
Blueprint : - read - annotate												X	X	X	X		X		
Cut (saw, shear)	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X

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TINNERS

KNOWLEDGE	Protective cones & squares	Smoke stacks	Fan housings	Safety shields (plexiglass)	Guards (chain, gear, scale)	Duct work (exhaust & combat)	Retaining rings	Floor plates	Flashing	Signs	Safety mirrors	Heater boxes	Trumpet brick support clamp	mild brush	wire brush spacer	roof	conveyor	wear strips (ARM I	rubber asbestos protective curtains
General Knowledge																			
Join (punch fastener)	x	x	x	x		x		x	x				x	x			x	x	
Bend				x		x						x	x						
Roll		x					x												
Drill		x	x	x		x		x	x				x	x	x	x	x		
Specialized Knowledge																			
Hydrochloric acid		x	x	x		x		x	x	x		x	x	x	x	x	x	x	
Asbestos				x															x
Metallurgy								x										x	